U. S. NAVAL ORDNANCE LABORATORY
White Oak, Silver Spring, Maryland

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NASA QUARTERLY PROGRESS REPORT

HYPERSONIC BOUNDARY LAYER TRANSITION

Boundary layer transition Reynolds numbers have been determined for 6.3-degree semi-vertex angle cones at Mach numbers 9 and 13.3. The transition Reynolds numbers were determined primarily by measuring the variation of the total drag coefficient with body Reynolds number. When the body Reynolds number was increased sufficiently to cause transition to occur on the aft portion of the model, a marked increase in the drag coefficient was observed. This was due to the higher skin friction drag associated with the area subjected to the turbulent boundary layer. The data are shown in figure 1.

An additional analysis was made of the data by investigating the nature of the base flow. For all launchings at each Mach number where the body Reynolds number was less than the apparent transition Reynolds number, the wake flow at the base was predominately laminar. These data are indicated in figure 1 by open symbols. For all launchings at body Reynolds numbers greater than the transition Reynolds number, the wake flow was predominately turbulent. Therefore, for this case, transition would have to occur on the body. These launchings are indicated in figure 1 by solid symbols. The transition Reynolds number that is indicated by the wake data is the same as that determined by the drag data.

A third preliminary analysis has been made of the launchings with transition on the body. For these launchings, an attempt was made to measure the length of laminar flow on the body as observed on the range shadowgraph photographs. A transition Reynolds number was then calculated by using the average observed length of laminar flow and the measured flow properties. The transition Reynolds number at Mach number 9 obtained by this method is 6.2×10^6 and at Mach number 13.3 is 8.7×10^6. These values agree very well with the values of 6.5×10^6 and 8.7×10^6 for Mach numbers 9 and 13.3, respectively, obtained by the drag method. An attempt will be made to measure the length of laminar flow on the range photographs more accurately, but the results are not expected to vary appreciably from the preliminary results mentioned above.

ENCLOSURE (1)

Summary

All range testing for the program has been completed. The results indicate that the transition Reynolds number for a 6.3-degree semi-vertex angle cone is 6.5×10^6 for Mach number 9 and 8.7×10^6 for Mach number 13.3.

A final report will be prepared during the next quarter.

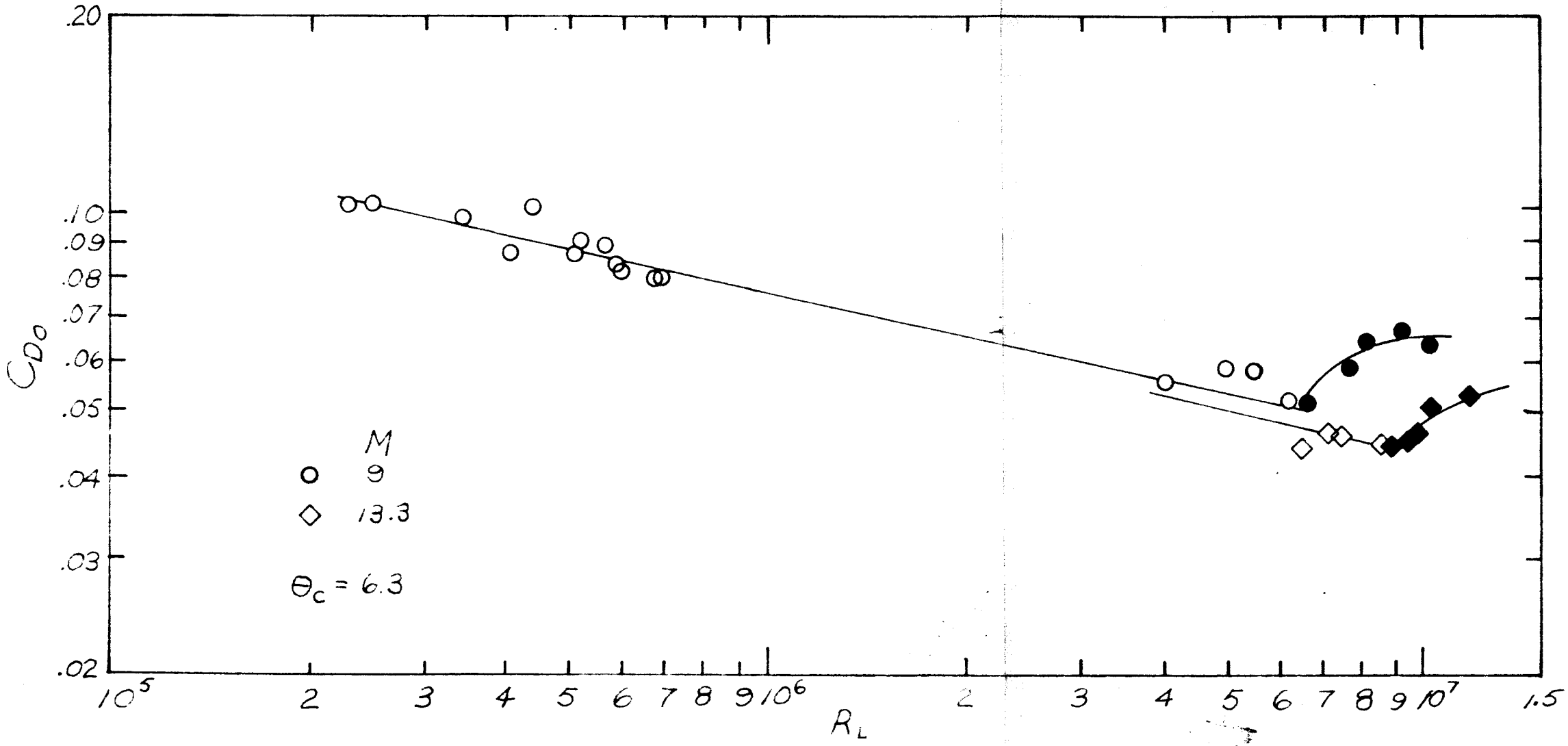
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
C_{D_0}
M
9
13.3
$\theta_c = 6.3$
10^5
2
3
4
5
6
7
8
9
10^6
2
3
4
5
6
7
8
9
10^7
1.5
R_L

FIGURE 1